UNIVERSITY OF PENNSYLVANIA

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IN COLLABORATION WITH

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A THESIS

IN PHYSIOLOGICAL CHEMISTRY

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THE INORGANIC COMPOSITION OF THE PAROTID SALIVA OF THE DOG AND ITS RELATION TO THE COMPOSITION OF THE SERUM

INTRODUCTION

In studies on secretion much use has been made of saliva and the salivary glands, because of the ease with which this fluid can be obtained and the ready accessibility of the glands. Since the time of Ludwig, it has been known that the composition of saliva varies greatly with the type of stimulus. Clark and Shell (1) in an elaborate study found no correlation between diet and the composition of human saliva. However, Clark and Levine (2) reported that an increase in the phosphate concentration of the blood, following the ingestion of soluble phosphates, produced a large increase in the phosphate concentration of the saliva. But ingestion of sodium chloride resulted in only a small increase in the chloride concentration of the serum and no significant changes in the chloride concentration of the saliva. Baxter (3, 4) reported variations of ash, organic matter, and chloride which occurred during the progress of secretion. Werther (5), studying the submaxillary gland, showed that chloride and water-soluble salts (which were probably mainly sodium chloride and bicarbonate) were secreted in higher concentration when the rate of secretion was considerably increased. Gregersen and Ingalls (6) have recently demonstrated that sodium but not potassium varies in this way. The submaxillary saliva of the dogs studied was secreted after chorda tympani and pilocarpine stimulation.

Wide variations occur in the composition of saliva obtained from different species. The bulk of the inorganic portion of human saliva consists of potassium and phosphate. Chloride, sodium, calcium, and carbon dioxide are present in fair amounts. The inorganic constituents of dog parotid saliva, as will be seen from our work, consist largely of sodium, bicarbonate, and chloride with small amounts of potassium and calcium. Furthermore, it has been found, not only that the salivary glands of different species of animals may produce saliva of widely different composition as regards inorganic constituents but also that the saliva produced by one individual may show considerable fluctuations.

In order to study the variations in composition of saliva in detail and to determine the effect of varying the composition of the blood circulating through the glands, the following experiments were carried out.

Methods

Normal dogs were anesthetized with amytal injected intravenously or intraperitoneally, and both of Stenson's ducts were cannulated. The cannulas were made by cutting off the tips of hypodermic needles of suitable bore, and polishing the ends. By means of adapters and capillary glass tubing, which was clamped firmly to the operating table, the cannulas were connected to graduated, mercury-filled tonometers. The animal was placed on its back and its dorsal jaw so fastened that the mucus and saliva coming from other glands would not drain down the throat. It was found that a free flow of saliva could best be obtained by distending the oral cavity and holding the cheeks stretched away from the gums during the experiment. Pilocarpine, dissolved in physiological saline solution, was administered in doses of 0.3 mg. per kilo of body weight, either intravenously by way of the external jugular vein or intraperitoneally. The intraperitoneal injection gave a slower but more uniform flow of saliva.

Four or more samples of saliva, usually about 15 cc. each, were collected from both right and left parotid glands. Usually one injection of pilocarpine was sufficient to obtain enough saliva for one sample. After two or more control samples of saliva had been collected, the salt solutions were injected intravenously, into the femoral vein, unless otherwise stated. Blood was collected

under oil from one of the external jugular veins at the beginning of the experiment, immediately after the injection, and at the end of the experiment.

Total carbon dioxide was determined on both saliva and serum immediately at the conclusion of the experiment by the method of Van Slyke and Stadie (7), with a calibrated micro volumetric apparatus. Since the amount of H_2CO_3 in the saliva never amounted to more than 1 or 2 milli-equivalents, as can be calculated from the pH and total CO_2 measured, and the quantity of Na_2CO_3 was negligible, the total CO_2 measured came largely from bicarbonate and has been calculated as such. The pH determinations were made immediately after collecting the sample. Since only relatively wide variations appear to be significant, determinations were made colorimetrically at 38°. Phenol red was used as the indicator, and standard buffers were prepared in tenths of a pH unit, according to Clark (8). Chloride was determined by Wilson and Ball's (9) modification of Van Slyke's method. Serum calcium was determined according to Clark and Collip (10).

Total solids were determined by drying overnight at 100°. All other determinations were made on ashed material. The saliva was ashed easily; large platinum evaporating dishes were used, and the procedure suggested by Stolte (11) was followed. The ash was dissolved by adding 1 cc. of 1.0 N hydrochloric acid, and made up to 10 cc. in small calibrated flasks. Aliquots were used for the following determinations. Sodium was determined by the method of Barber and Kolthoff (12) and potassium by the titration method of Shohl and Bennett (13). Instead of using a "glass bead filter" as described by the latter authors, it was found to be more convenient to use a filter prepared as follows: A small perforated platinum disk was supported on a shoulder ground in the apex of a 1 inch glass funnel, suction was applied, and an asbestos mat built up in the usual way. Calcium was precipitated with ammonium oxalate. The solution was made neutral to methyl red by means of dilute ammonium hydroxide, and after standing 2 hours the precipitate was filtered on the micro filters described above, washed with 3 cc. of 2 per cent ammonium hydroxide, then dissolved in 1.0 N sulfuric acid and titrated hot, with standard potassium permanganate.

The averages of duplicate determinations are given in Tables I to

V. In most experiments saliva was collected from both right and left parotid glands. Samples obtained at the same time from the two sides have similar composition unless the rates are very different. On account of this great similarity data are given for saliva obtained from one side only. Likewise, although two or more experiments dealing with each type of injection were made, only one typical example of each is reported in order to save space.

Results

During the course of an experiment, although a great deal of fluid was lost from the animal, blood of fairly constant composition was circulating through the glands (see Table I). In typical experiments, dogs of from 15 to 20 kilos of body weight excreted from 75 to 150 cc. of parotid saliva and from 200 to 400 cc. of saliva from the other glands as well as from 100 to 300 cc. of urine. Defecation usually occurred. Meanwhile, the serum-cell ratio, as estimated by centrifuging, showed a progressive change from the usual 1:1 ratio, to values as low as 1:3 or 1:4. In view of the great loss of fluid from the animal, the relative constancy of composition of the serum is remarkable.

The data obtained in a typical control experiment are presented in Table I. Additional control data are furnished by each of the other experiments in which several samples of saliva were collected as controls before the injections of the salt solutions. The data so obtained serve not only as a basis for the interpretation of the results of the injections but also show the variations which may occur from individual to individual. The control data demonstrate that while saliva obtained from different dogs may vary in the concentration levels of inorganic constituents, the quantitative composition of all samples but the initial, from any particular animal, remains moderately uniform.

An inspection of the data from all experiments reveals that the sum of the measured inorganic anions, expressed as milli-equivalents per liter, is greater than that of the inorganic cations. This preponderance of acid is especially marked in the first sample. Since the pH ranged from 7.4 to 7.9, some base other than those studied must have been present. It is probably not mucin as this protein shows acidic properties and presumably binds base in the saliva.

TABLE I

Control

Dog 16, male, weight 22.8 kilos.

	Blood serum			Gland	Saliva				
Sample No.....	1	2	3		1	2	3	4	5
Time of collection	10.15 a.m.	11.50 a.m.	1.40 p.m.		10.10–10.25 a.m.	10.28–11.15 a.m.	11.17–11.57 a.m.	12.00 m.–12.57 p.m.	1.00–2.10 p.m.
Volume, *cc*.....	35*	40*	35*	R.	12.0	12.5	20.0	16.0	18.5
				L.	13.5	15.0	12.0	19.5	20.0
Rate, *cc. per kg. per hr*.....				R.	2.1	0.7	1.3	0.7	0.7
				L.	2.5	0.9	0.8	0.9	0.7
Solids, *per cent*....				R.	1.523	1.130	1.070	1.054	1.102
				L.	1.387	1.129	1.031	1.066	1.063
Ash " "				R.	0.911	0.851	0.874	0.844	0.906
				L.	0.883	0.859	0.841	0.853	0.903
pH.....				R.	7.7	7.7	7.7	7.7	7.7
				L.	7.7	7.6	7.7	7.7	7.7
HCO_3, *m.-eq. per l.*	26.4	23.8	21.8	R.	57.7	54.3	59.4	62.9	63.6
				L.	62.6	55.3	57.1	61.8	69.1
Cl " " "	110.3	107.5	106.6	R.	103.7	100.1	97.4	88.3	86.7
				L.	98.8	99.9	96.2	89.4	80.6
Na " " "	130.6	135.6	126.3	R.	130.2	123.4	132.9	127.0	129.3
				L.	127.6	116.7	122.7	128.4	129.7
K " " "	4.2	3.6	4.5	R.	12.3	11.1	10.3	10.8	10.3
				L.	10.5	8.6	11.3	10.9	10.8
Ca " " "	5.2	5.1	5.3	R.	9.4	8.4	7.4	6.8	5.9
				L.	10.3	7.8	7.6	6.8	6.2

Pilocarpine was given intravenously at 10.03, 10.30, and 11.07 a.m.

* Amount of whole blood.

In general, the initial sample of saliva was richer in total solids than subsequent samples. Baxter (3, 4) reports similar findings. This variation was due largely, though not entirely, to organic material, as is shown by the amount of ash. The difference, however, between total solids and ash does not give a true measure of of the amount of organic material present, for during the ashing process there is a loss of inorganic material due to volatilization of ammonium salts if present and of part of the CO_2 of the bicarbonate. On the other hand, there may be small gains from the sulfur and phosphorus of the proteins.

The chloride concentration of the saliva, which was always lower than that of the serum, varied in the initial samples from different animals within wide limits; *i.e.*, from about 30 to 105 milli-equivalents per liter. There is a tendency toward a progressive drop in the chloride content of successive samples during an experiment. (See Table I.) This phenomenon at times reached much greater proportions than those shown by the control experiment. A slight decrease in the chloride concentration of the serum usually occurred simultaneously.

The total carbon dioxide concentration of the saliva is approximately double that of the blood serum. This constituent exhibited less variation among individuals than the chloride, and remained at a fairly constant level throughout the major part of the experiment. Occasionally toward the end of an experiment, an inexplicable rise in total carbon dioxide content of the saliva occurred, sometimes reaching values double those of the previous level. The total carbon dioxide concentration of serum usually showed a decrease during the course of the experiment.

The sodium concentration of the saliva was always (with the exception of one experiment (Table I)) lower than that of serum. It ranged from 48 to 133 milli-equivalents per liter. The fluctuations during an experiment were considerable, due partly, no doubt, to variations in rate of flow, as observed by Gregersen and Ingalls (6), in submaxillary saliva. An effort was made to keep the rate of flow uniform in our experiments, but with only occasional injections of pilocarpine this was obviously impossible. The figures quoted in Tables I to V represent average rates which in many instances were far from uniform for the period. However, in continuous experiments such as ours the rate of flow was probably

only one factor which influenced the concentration of the various constituents. For example, Table IV (Periods 1 to 4) shows variations in rates of flow and concentrations of constituents following one injection of pilocarpine. The rate of flow during the collection of the first sample was higher than during subsequent collections and the concentration of sodium as well as of all the other constituents was higher. In Periods 2, 3, and 4, when the rate of flow was not diminishing and was probably reasonably constant, the concentrations of sodium fell continuously. The same was true for the chloride. It is also worthy of note that the maximum concentrations of sodium observed in this study (Table I) were not associated with rates of flow above those in other experiments.

As a rule potassium concentrations were high for the first sample, lower for the second, and then tended toward a plateau level of 10 to 12 milli-equivalents per liter. These values are 2 to 4 times as high as the potassium concentration of the serum.

The calcium concentration of saliva was almost always higher than that of serum, and usually ranged from 6 to 8 milli-equivalents per liter. Occasionally initial values were as high as 10 milli-equivalents per liter.

The pH remained quite constant throughout control experiments. While parallel fluctuations of total carbon dioxide and pH in the experiments reported in Tables I and III indicate the possibility of a relationship between these two factors, Table V shows wide discrepancies. Furthermore, saliva from different animals may have the same pH but differ much in total carbon dioxide concentration. For example, Table III shows a pH of 7.9 accompanied by a bicarbonate concentration of 85.2 milli-equivalents per liter, and in Table V an identical pH value is found with a saliva which contained only 56.6 milli-equivalents. While the bicarbonate concentration undoubtedly is concerned with the pH, other factors must enter also. No correlation, such as Ball (14) reported for pancreatic juice, between rate of secretion and pH could be discerned in these experiments.

The secretion of sodium and chloride seems to be so controlled by the gland that the concentrations of these substances show little change on the intravenous injection of sufficient 10 per cent sodium chloride to cause a marked rise in the sodium and chloride concentration of the serum (see Table II).

TABLE II

Injection of Sodium Chloride and Calcium Chloride

Dog 6, male, weight 20.0 kilos.

	Blood serum			Right parotid saliva				
Sample No.	1	2	3	1	2	3	4	5
Time of collection	10.50 a.m.	11.40 a.m.	2.15 p.m.	10.45–11.04 a.m.	11.35–11.58 a.m.	12.00 m.–12.45 p.m.	1.42–2.05 p.m.	2.07–2.25 p.m.
Volume, *cc*.....	40*	40*	40*	12.0	20.0	15.0	20.0	10.0
Rate, *cc. per kg. per hr*.....				1.9	2.6	1.0	2.6	1.7
Solids, *per cent*.....				1.420	0.960	0.809	0.805	0.775
Ash " "				0.750	0.783	0.723	0.726	0.683
HCO_3, *m.-eq. per l.*	23.9	22.5	21.5	51.7	47.8		47.6	
Cl " " "	107.9	124.9	130.4	84.2	97.9	80.4	75.3	
Na " " "	136.5	150.4	156.9	114.3	119.6	110.9	96.6	96.0
K " " "	5.5	4.8	5.4	11.2	9.8	9.4	13.7	13.3
Ca " " "	6.4	5.8	12.5	9.0	8.7	7.6	17.2	14.6

Pilocarpine was given intravenously at 10.45, 11.35 a.m., and 1.50 p.m. 92 cc. of 10 per cent NaCl were given intravenously from 11.16 to 11.32 a.m. 25 cc. of 10 per cent $CaCl_2$ were given intravenously from 1.15 to 1.20 p.m.

* Amount of whole blood.

TABLE III

Injection of Sodium Carbonate

Dog 13, female, weight 20.5 kilos.

	Blood serum				Right parotid saliva				
Sample No.	1	2	3	4	1	2	3	4	5
Time of collection	11.15 a.m.	12.19 p.m.	1.27 p.m.	3.30 p.m.	10.21–11.02 a.m.	11.02–11.37 a.m.	12.23–1.22 p.m.	1.27–2.12 p.m.	2.16–3.30 p.m.
Volume, *cc.*	35*	15*	35*	50*	8.5	14.0	26.0	18.0	18.0
Rate, *cc. per kg. per hr.*					0.6	1.2	1.3	1.2	0.7
Solids, *per cent*					0.580	0.344	0.599	0.836	0.914
Ash " "					0.388	0.254	0.512	0.736	0.763
pH					7.6	7.5	7.7	7.8	7.9
HCO_3, *m.-eq. per l.*	23.1	30.9	48.7	38.8	38.8	34.7	59.3	81.7	85.2
Cl " " "	113.5	112.1	108.4	111.2	37.5	26.5	18.6	55.9	56.3
Na " " "	148.3	140.4	171.4	163.5	48.8	48.2	76.1	117.7	122.6
K " " "	3.7		3.3	3.0	10.2	6.1	6.5	5.2	5.6
Ca " " "	5.8		5.1	5.7	5.8	5.0	6.2	6.4	5.9

Pilocarpine was given intravenously at 10.08, 11.18 a.m., 12.47, 1.51, and 2.30 p.m. 156 cc. of 10 per cent Na_2CO_3 were given intravenously from 11.54 a.m. to 1.33 p.m.

* Amount of whole blood.

The results of sodium carbonate injections stand in striking contrast to the above. When the concentrations of sodium and total carbon dioxide in the serum were increased by intravenous injections of 10 per cent sodium carbonate, a prompt increase of both the sodium and total carbon dioxide of the saliva occurred (Table III). As one would expect, the pH of the saliva was increased following the injections.

The ratio of the concentration of the total carbon dioxide of the serum to that of the saliva may differ from animal to animal but

Injection o

Dog 10, male, weight 17.4 kilos.

	Blood serum			
Sample No.	1	2	3	
Time of collection	10.20 a.m.	1.11 a.m.	2.00 p.m.	
Volume, *cc.*	40*	40*	80*	
Rate, *cc. per kg. per hr.*				
Solids, *per cent*				
Ash " "				
HCO_3, *m.-eq. per l.*	26.8	23.8	22.6	64
Cl " " "	108.3	109.8	114.3	85
Na " " "	130.3	142.8	146.1	119
K " " "	3.3	5.1	5.9	12
Ca " " "	6.0		6.4	8

Pilocarpine was given intravenously at 10.16, 11.48 a.m., 12.34, and 1.32 p.m.
* Amount of whole blood.

tends to remain the same for each animal after the injection. The same cannot be said of the chloride ratio, and the sodium ratio exhibited constancy only in the sodium carbonate experiments.

Following the injection of sufficient calcium chloride solution to more than double the calcium concentration of the serum, a large increase in the calcium of the saliva occurred (Table II). The ratio of the concentrations of the calcium of the serum to that of the saliva usually tended to increase slightly.

The injections of potassium salt solutions were made intra-arterially to lessen the toxic effect. The animals seemed to be able

to withstand the injection of potassium as the carbonate better than as the chloride. Because control experiments indicated that potassium concentrations were more uniform some time after the experiment was begun, the potassium salt injections were delayed until three or four control samples had been collected (see Table IV). Although a rise in the concentration of the potassium of the saliva followed each injection, the variations are of doubtful significance. On the supposition that potassium as the carbonate might exhibit a behavior similar to that of sodium carbonate, intraarterial

IV
sium Chloride

	Left parotid saliva					
	2	3	4	5	6	7
m.	10.26–10.42 a.m.	10.42–10.59 a.m.	10.59–11.21 a.m.	11.27 a.m.–12.17 p.m.	12.31–1.08 p.m.	1.14–2.10 p.m.
	5.5	5.5	8.5	28.0	15.5	18.0
	1.2	1.0	1.4	1.7	1.4	1.0
	0.860	0.750	0.699	1.157	1.016	0.847
	0.650	0.535	0.493	0.673	0.672	0.619
		55.6		64.7		82.0
	60.6	49.2	48.4	53.1	37.4	26.5
	103.5	84.3	71.3	98.0	100.0	85.3
	5.3	4.3	5.4	9.0	11.4	12.3
	5.8	5.4	7.0	8.2	7.4	8.1

of 10 per cent KCl were given intraarterially from 12.25 to 12.56 p.m.

injections of 10 per cent potassium carbonate were made. The results obtained indicated no such parallelism. In fact, values for the potassium content of saliva, obtained in other experiments in which no potassium was injected, were often just as high or higher.

When hydrochloric acid was injected (see Table V) a sharp drop in the total carbon dioxide content of the serum followed, as was to be expected. Contrary to the report of Hug and Marenzi (15) no regular fall in the carbon dioxide content of the saliva was noticed. However, it was found, as the above investigators re-

TABLE V

Injection of Hydrochloric Acid

Dog 22, female, weight 8.7 kilos.

	Blood serum			Gland	Saliva			
Sample No.	1	2	3		1	2	3	4
Time of collection	10.45 a.m.	11.17 a.m.	12.35 p.m.		10.12–10.45 a.m.	11.00–11.20 a.m.	11.30 a.m.–12.00 m.	12.04–12.15 p.m.
Volume, *cc.*	40*	40*	80*	R.	9.0	9.5	12.5	4.0
				L.	10.0	8.5	12.5	4.0
Rate, *cc. per kg. per hr.*				R.	1.9	3.2	2.9	2.5
				L.	2.1	2.9	2.9	2.5
Solids, *per cent*	9.540	9.850	9.483	R.	0.977	0.770	0.870	0.960
				L.	1.030	0.750	0.836	0.940
Ash " "	0.833	0.883	0.843	R.	0.587	0.530	0.586	0.350
				L.	0.550	0.490	0.568	0.490
pH				R.	7.7	7.7	8.0	7.8
				L.	7.7	7.8	8.0	7.9
HCO_3, *m.-eq. per l.*	19.3	14.6	15.4	R.	54.8	47.4	47.6	57.4
				L.	51.7	44.3	46.3	56.6
Cl " " "	111.8	112.3	111.8	R.	51.8	54.8	55.3	35.5
				L.	56.9	53.5	55.8	40.5
Na " " "	130.5	135.7	131.2	R.	77.3	69.1	77.7	60.6
				L.	83.6	70.3	79.8	76.7

Pilocarpine was given intraperitoneally at 10.00, 10.55, 11.37 a.m., 12.05, and 12.22 p.m. 18 cc. of 1.0 N HCl were injected in the femoral artery from 10.58 to 11.13 a.m. 9 cc. of 1.0 N HCl were injected in the femoral artery from 12.11 to 12.19 p.m. Saliva ceased flowing at 12.15 p.m.

* Amount of whole blood.

port, that a rise in pH occurred. No explanation is offered for this phenomenon. In several other experiments not reported in detail, the injection of acid was followed by a cessation in the flow of saliva in spite of repeated injections of pilocarpine.

Qualitative tests on the saliva showed that sulfocyanate was absent and that inorganic sulfate was present in small amounts. Additional sulfur was present in some other combination, possibly as an organic ester. This was shown by the relatively much greater precipitate of barium sulfate obtained with ashed saliva as compared with the unashed. Moreover, when the fresh saliva was allowed to stand in contact with dilute hydrochloric acid overnight, a large increase in ionic sulfate was noted. Quantitative analyses of several samples of parotid saliva showed magnesium 0.6 to 1.2 milli-equivalents per liter and phosphate 0.4 to 0.7 milli-equivalents per liter.

DISCUSSION

The saliva secreted by the parotid gland of the dog, under pilocarpine stimulation, is markedly different from the serum. A comparison of the two fluids is shown in Table VI. Bicarbonate, potassium, and calcium are usually present in higher concentration in the saliva than in the serum; chloride and sodium are lower in saliva. It is thus evident that saliva is not a simple transudate or dialysate. There appears to be no tendency toward a diminution of the efficiency of the controlling mechanism with regard to any constituent studied after injections which alter the composition of the serum considerably.

The pancreas produces an alkaline secretion of quite different composition from the saliva. Ball showed (16), in this laboratory, that the sodium and potassium apparently filter through the pancreas because he found the concentrations are the same in the water of both the pancreatic juice and serum. The calcium, magnesium, and phosphate are far below the concentrations in the serum. The chloride and bicarbonate vary with the rate of flow of the pancreatic juice, the bicarbonate rising and the chloride falling as the rate increases. The variations of these two ions appear to control the pH of the secreted juice. Injections of inorganic salts do not alter appreciably the above relations.

Ball found that pancreatic juice and serum had the same osmotic

pressure. No such equality appears to exist between saliva and serum. Nolf (17) reports freezing point depressions for the submaxillary saliva of the dog of −0.193° to −0.396° when obtained by chorda tympani stimulation, and −0.109° to −0.266° for the spontaneously secreted saliva. The serum had a freezing point depression of −0.560°. The freezing point depression for dog parotid saliva calculated on the basis of the inorganic concentration as shown in Table VI is about −0.48°.

TABLE VI

Comparative Composition of Serum, Parotid Saliva, Pancreatic Juice, Dialysates, and Transudates of the Dog

The values are expressed as milli-equivalents per liter.

	Serum	Parotid saliva	Pancreatic juice	Dialysate	Transudate
HCO_3	25.3	55.1	100.0	22.2	26.1
Cl	110.1	81.7	51.0	122.8	126.0
Na	135.2	106.0	158.0	147.0	149.7
K	4.5	10.1	6.3	3.8	5.0
Ca	5.9	7.7	1.0	3.2	3.5

The figures given for parotid saliva are average values taken from control data. The values for pancreatic juice are from the work of Ball (16). The figures for dialysates and transudates are taken from the papers of Greene and Powell (18) and Greene, Bollman, Keith, and Wakefield (19) respectively.

SUMMARY

1. Saliva obtained from the parotid gland of the dog by means of pilocarpine stimulation was analyzed for total solids, pH, total carbon dioxide, chloride, sodium, potassium, and calcium.

2. Total carbon dioxide, calcium, and potassium were found to be present in the saliva in greater concentration than in the blood serum, while sodium and chloride concentrations were lower in saliva than in the serum.

3. The intravenous injections of solutions of calcium chloride and of sodium carbonate in quantities sufficient markedly to increase the concentrations of their respective ions in the blood were followed by increases in the concentration of these substances in the saliva.

4. The injection of concentrated solutions of sodium chloride, potassium chloride, and potassium carbonate into the blood stream did not materially affect the composition of the saliva.

5. The intravenous injections of either hydrochloric acid or of sodium carbonate resulted in an increase of the pH of the saliva.

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